Utilization of Sawdust and Coconut Coir Fiber for producing Noise reducing Wall Tile

O.S. Chathurangani[1],
W.J.M.K. Perera[2],
H.M.N.S. Kumari[3],
G.H.M.J. Subashi De Silva[4],
G.S.Y. De Silva[5],
Department of Civil and Environmental Engineering, University of Ruhuna.
e-mail: [1]shameera.eng@gmail.com
[2]keshithaperera@yahoo.com
[3]hmnswijesinghe@gmail.com
[4]subashi@cee.ruh.ac.lk
[5]sudhira@cee.ruh.ac.lk

Abstract

Today noise control has become a major requirement to provide a calm and pleasing living environment. With the technological development, industrial noises, which are mainly induced by machines, affects negatively on the day-today life of surrounding people. They have faced with many problems mentally and healthily. Noise control and its principles play an important role in creating a pleasing environment. This can be achieved when the intensity of sound is brought down to a level that is not harmful to human ears. Noise barriers, noise absorbers, reflectors are used for noise controlling purpose. This research was conducted to investigate the potential of using saw dust and coconut coir fiber as sound reducers for giving a solution for the existing industrial noise problem. Wall tiles were made by using saw dust. The effects of the thickness of the tiles, their surface condition and the sawdust particle sizes on noise controlling properties were investigated. In addition, panels were casted mixing coconut coir fiber with latex of rubber. Noise Reduction Co-efficient (NRC) of these tiles was investigated by using an experimental setup including signal generator, speakers and noise level meter. The results for the saw dust tiles have showed that there was a significant effect of the tile thickness, surface condition, mix proportion and sawdust particle sizes on NRC. The NRC values obtained for sawdust tiles ranged from 0.1 to 0.5 while that for the coir fiber panels was 0.01-0.6.

Key Words: Noise Reduction coefficient, Coconut coir fiber, Sawdust, Noise level meter

1. Introduction

With the technological development, noise has become a serious environmental problem. Industrial noise acts a vital role in causing this problem. In industry the main sources of causing noise are machines. It has been identified that the machine noises induced in the frequency range from 1 kHz to 8 kHz. The tolerance to noise levels of people varies considerably. The huge noises come from operating machines cause bad effects on the people. Negative effects of noise can be listed as hearing impairment, interference with speech communication, disturbance of rest and sleep, mental-health and performance effects, effects on residential behaviour and annoyance, as well as interference with intended activities [1, 2]. Therefore noise controlling is an urgent need.

In the case of noise controlling, glass wool and rock wool are currently used as materials for noise absorbing. However, it is widely argued that these materials have severe effect on human health. Therefore, an investigation of an alternative natural material for noise absorption purpose will enhance safety and sustainability. The capability of a material to absorb noise is measured by Noise Absorption Coefficient (NAC) which has been defined as the ratio of absorbed sound intensity to incident sound intensity [3].

This research is based on utilization of saw dust and coconut coir fiber to investigate Noise Reduction Coefficients [NRC (i.e., intensity of sound which is absorbed and reflected / intensity of incident sound)].

Saw dust is a by product of timber mills, composed with fine particles which are removed while sawing timber. The colour of sawdust changes from yellow to brown with the type of timber. Saw dust has a variety of practical usage including burning it as a fuel. Unless burning saw dust in a burner or used to make heat for other milling operations, saw dust has been piled in abundant quantities making environmental problems. Large quantities of saw dust that has been piled for long period may add harmful leachates into local water bodies creating an environmental hazard.

Coconut coir is a natural fiber and is extracted from husk, the fibrous outer covering of the coconut fruit (Cocos nucifera). Extraction of coconut coir from the husk is usually done by soaking the husk in the water and continuous pressing of the husk until fibers separate from the pith.

Saw dust and coconut coir fiber were often considered as waste and they were dumped into open spaces creating environmental pollution. Open dumping of the above materials is done probably because there was no market for either saw dust or coconut coir fiber in this current form. The value addition of the coconut coir fiber is insignificant, although they have been used into ropes. However, these wastes might rich with noise absorption properties. For example, Zulkifli et al. (2010) have investigated the noise absorption of coconut coir fiber [4]. Coconut Coir Fiber (CCF) panels had treated with latex during forming in order to bind well. They have found that in the frequency range of 78.13 Hz – 4766 Hz the NAC values increased with the increase of thickness of the sample.

Zulkifli (2009) has investigated the NAC of coir fiber and oil palm fiber. Latex has been used to provide the necessary cohesion between the fibers. They had conducted the test for 100 – 5000 Hz range of frequencies [5]. It was found that 30 mm thickness coir fiber panel had shown NAC greater than 0.6 for the frequencies above 800 Hz.

Therefore, it was expected that a wall tile manufactured using these waste would show noise absorption properties, although the affective usage of coconut coir fiber for noise reduction in the frequencies greater than 5 kHz was unknown.

Also use of these materials has advantages of being renewable, cheaper, abundance and less effect on health. The tile, which is capable of absorbing noise can be used to reduce noise pollution, that is frequently reported due to industrial noise. In the current research study, an attempt was made to utilize saw dust and coconut coir fiber to cast a wall tile and investigate its noise reduction properties.

2. Methodology

Methodology includes casting of wall tiles using saw dust, manufacturing of coconut coir fiber panels and setting laboratory experimental setups to investigate noise absorption properties of the tiles.

2.1 Casting tiles using sawdust

Saw dust is abundantly seen at timber mills. The saw dust that used for this research was obtained from a timber mill in wet zone (Galle). Colour of the sawdust was light brown (Figure 1). Six tiles were casted to investigate effects of particle size of the sawdust, mix proportion, tile thickness, and surface variation of the tile on noise reduction properties (Table 1).

For casting tiles, initially, cement (Ordinary Portland cement: OPC), sand were mixed with sawdust in weight basis with the pre determined mix proportion (Table 1). Sufficient water was added to mixture and mixed well and then poured into a mould having the size of 20cm x 20cm length and width and a height of 25mm (Figure 2). The 15mm, 20mm heights were marked by a thin line inside the mould for casting tiles with different thickness. Tiles were removed from the mould after one week.

Table 1: Experimental Program

Variations / *Tile Identification*	*Thickness of the tile (mm)*	*Mix proportions in weight basis*			*Size of saw dust particles*	*Surface of the tile*
		Cement	*Sand*	*Sawdust*		
1	*15*	*2*	*1*	*1*	*Small*	*Flat*
2	*25*	*2*	*1*	*1*	*Small*	*Flat*
3	*25*	*1.5*	*1*	*1*	*Large*	*Flat*
4	*25*	*2*	*1*	*1*	*Large*	*Flat*
5	*25*	*3*	*1*	*1*	*Large*	*Flat*
6	*25*	*1.5*	*1*	*1*	*Large*	*Grooved*
Coir fiber panel						
1	*20*	-	-	-	-	-

Based on the particle size, two samples of saw dust were selected: Sample 1(i.e.small), which includes particles below 0.85 mm size; Sample 2 (i.e. large), which includes particles between 1.7 and 2.36 mm. Two tiles were casted to investigate the effect of saw dust particle size. There the mix proportion was 2:1:1 Cement: Sand: Sawdust (C: S: SD) and the surface was flat for each tile.

In order to investigate the effect of thickness, tiles were casted with two different thicknesses: 15mm, 25mm. The mixed proportion for these tiles was 2:1:1 (Table 1). These tiles are having flat surface and casted with Sample 1 saw dust particles.

In order to investigate the effect of mix proportions, three different tiles were casted with different mix proportions. The mix proportions used were 1.5:1:1, 2:1:1, 3:1:1 C: S: SD. Other parameters: sawdust particle size (Sample 2), thickness (25mm) was kept constant for the three tiles and their surface were flat.

To investigate the effect of surface variation on noise absorption properties two tiles were prepared: One with flat surface and other one with a series of 10 mm deep grooves (i.e., three parallel grooves in each direction as shown in Fig.4). Mix proportion and the particle size for these tiles were kept as 1.5:1:1 C: S: SD and Sample 2.

Figure 1: Sawdust

Figure2: Mould

Figure 3: Sawdust tile (Flat surface)

Figure 4: Sawdust tile (Grooved surface)

2.2 Preparation of coir fiber panels

Coir fibers were collected from a village, where a coir fiber industry is functioning for producing ropes. Browned colour and 5 -10 cm length pieces of fibers were used for the preparation of panels. Latex of rubber was poured into a pan and the same volume of water was added make a liquid solution. Acetic acid was added (water: acid = 50: 1 in volume basis) into the solution for hardening process and mixed it well. Immediately coir fibers were laid randomly and again mixed well. The mixture was kept in the pan for 2 hours for hardening .Then it was taken out from the pan and put into the roller (the machine used for producing rubber sheets). This process is necessary for removing water. Then the mixture was kept in an oven at a temperature 40 – 50°C for 3 days. The produced panel (Figure 6) was 20mm in thickness (thickness was adjusted by the roller).

Figure 5: Coconut coir fiber

Figure 6: Coir fiber panel

2.3 Experimental Setup

In this study, the experiment was conducted using the experimental setup prepared in the Department of Electrical and Information Engineering, Faculty of Engineering. University of Ruhuna. It included a signal generator (GwInstek GFG8255A), Noise level meter (SL-1350), speaker and a wooden box. Figure 7 shows the schematic diagram of the experimental setup that was used to investigate noise level reduction. Signal generator was used to provide sound signals in the frequency range of 1-8 kHz. The sound related to the given frequency was obtained by using a speaker. Sound level meter was placed inside a wooden box having 15cm×15cm×30cm width, height and length so as to measure the noise levels in decibels (dB) before and after placing of the tile. A wooden box was used to minimize the effect of background noise on the noise level measurements. The tile (or the panel) was placed between the speaker and the box as shown in Figure 7. The distance from the speaker to the sound level meter was kept constant (50mm from the front face of speaker) to minimize the effect of distance on the noise level measurements.

The experiment was conducted during night times (i.e., calm environment) so as to reduce the effect of environmental noise on the measurements.

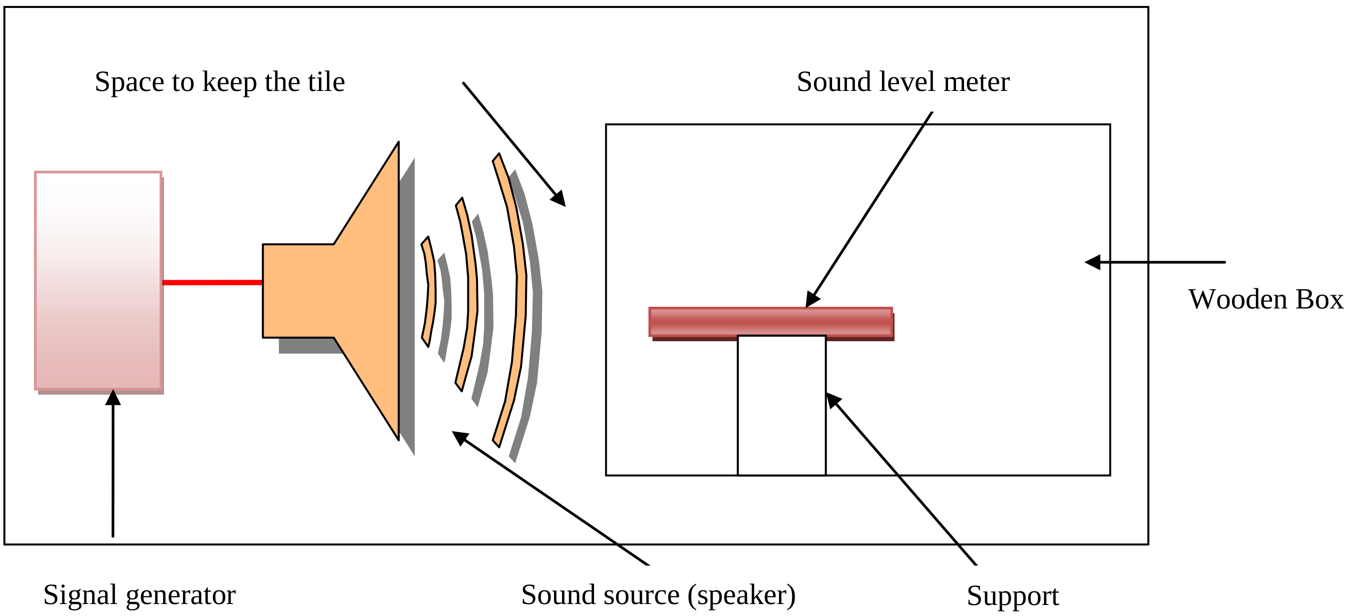

Figure 7: Schematic diagram of the experimental setup

As in Figure 7 noise level measurement (a in dB) was recorded before placing the tile. This measurement was continuously recorded at 0.25 kHz intervals in the frequency range 1- 8 kHz. Then the tile was placed at the space which has been shown in Figure 7 and the noise level measurement (b in dB) was recorded at all the previous frequencies.

2.3.1 Data analysis

Noise Reduction Coefficient (NRC) was determined as the ratio between the noise reductions due to the tile to the incident noise level without placing the tile. The noise reduction was the difference between the noise level measurement without placing the tile (i.e., a in dB) and with placing the tile (i.e., b in dB).

$$\text{Noise Reduction Coefficient (NRC)} = (a - b)/a$$

3. Results

3.1 Noise reduction co-efficient of saw dust tile

3.1.1 Effect of tile thickness

Figure 8 shows the noise reduction co-efficient for the tiles having thicknesses of 15 and 25mm. It can be clearly seen that noise reduction coefficients of 25mm thick tile has gained generally higher values than the 15 mm thick tile, except at 6 and 7 kHz. In the frequency range of 3-5.5 kHz the NRC for the 25 mm tile varied between 0.25-0.45 ranges.

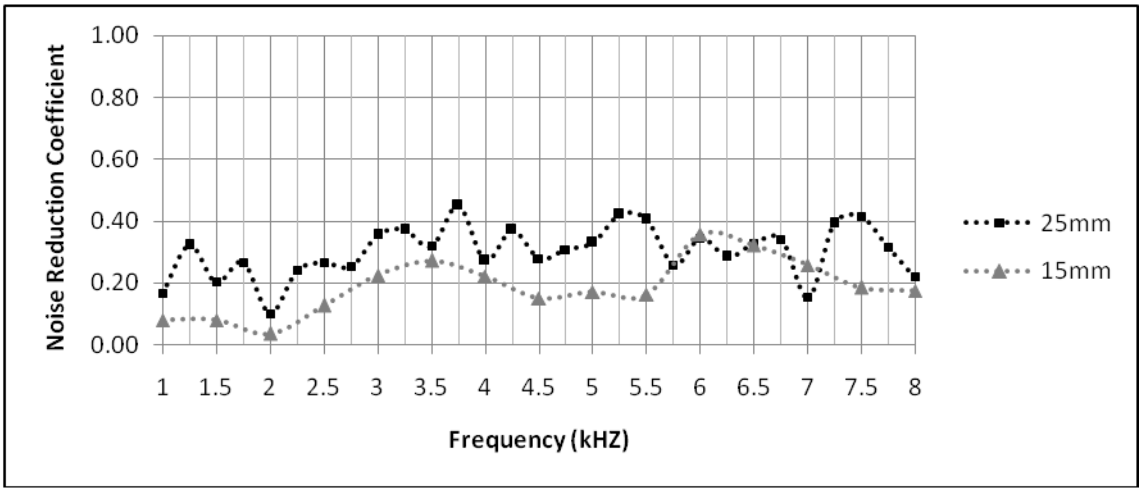

Figure 8 Noise Reduction coefficient for different thicknesses of the tiles (C: S: SD = 2:1:1, sawdust Sample 1

3.1.2 Effect of particle size of saw dust

Figure 9 shows the variation of NRC with the sawdust particle size while keeping other variables constant. In most of the frequencies, NRC is greater for the tile cast with Sample 2 (i.e., large particles) than that for the tile cast with Sample 1 (i.e., small particles). For the tiles with small saw dust particles, NRC increases up to 0.5. In the measured frequency range the NRC values have varied mostly between 0.2- 0.4.

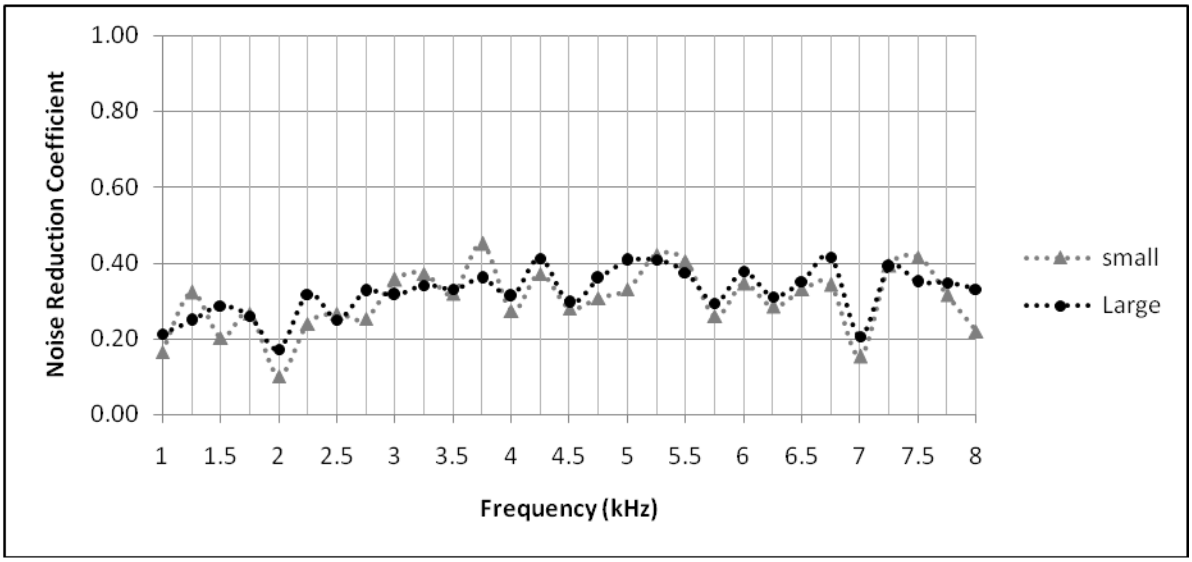

Figure 9 Noise reduction coefficient for tiles having different particle sizes (i.e., Sample 1 and Sample2, C: S: SD = 2:1:1)

3.1.3 Effect of surface variation of tiles

Figure 10 shows the noise reduction co-efficient for the tiles with grooved surface and flat surface. It can be seen from the figure that, there is an increase of NRC in the frequency range of 1- 8 kHz except at 5 and 5.5 kHz for the tile with grooved surface than that for the tile with flat surface. The maximum NRC, about 0.5, was observed at 7.5 kHz.

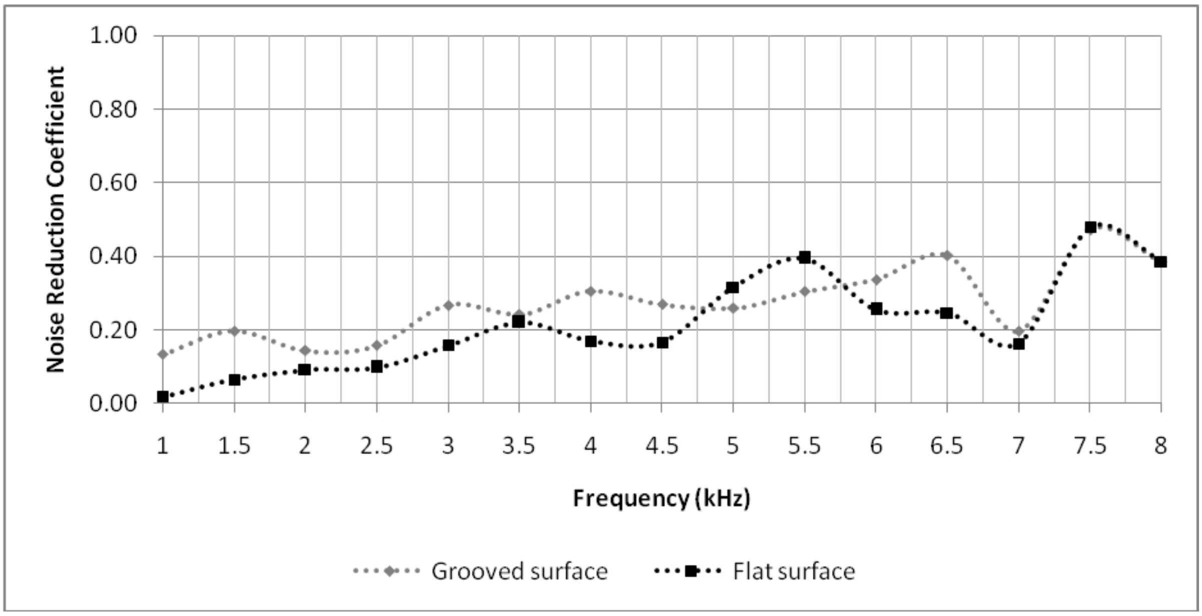

Figure 10 Noise Reduction Coefficient for the surface variation of tiles (C: S: SD = 1.5: 1: 1)

3.1.4 Effect of mix proportion of tiles

Figure 11 shows the variation of NRC with mix proportions. There it can be observed up to 4.5 kHz the NRC values of tile having 1.5: 1: 1 mix ratio has lesser values than the other two tiles. In 6- 7 kHz range the NRC has increased with increase of mix ratio.

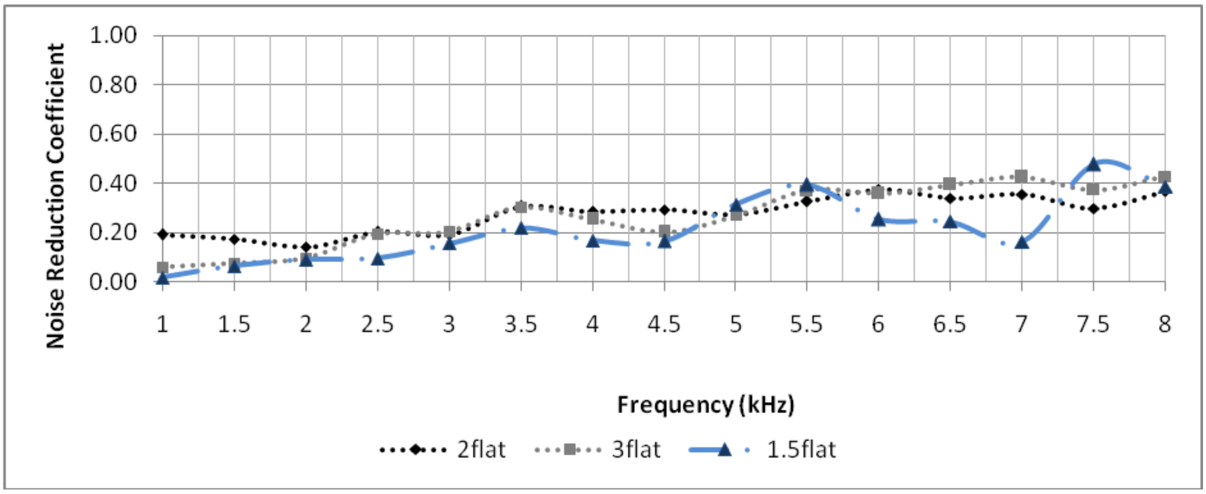

Figure 11 Noise Reduction Coefficient for the tiles with different mix proportions (Sawdust Sample 2)

Noise Reduction Co-efficient for the coir fiber panel (20mm thickness) has the peak of 0.5 at 8 kHz (Figure 12). However, it may be seen effective in all measured frequency range while having more effective in the range of 5.5 – 8 kHz.

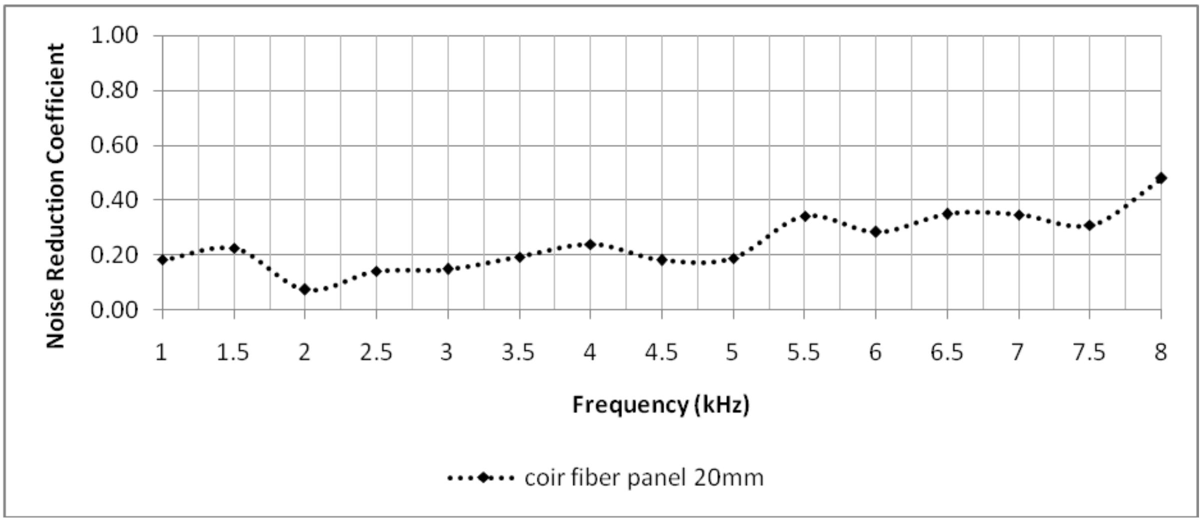

Figure 12 Variation of Noise Reduction Coefficient with Frequency for the coir fiber panel

4. Discussion

4.1 Noise Reduction of saw dust tiles

4.1.1 Effect of thickness of the tile

There is an increasing of Noise Reduction Coefficient with the increase of tile thickness (Figure 8). This trend was clearer in the frequency range of 1- 6 kHz and less clear in frequencies above 6 kHz. The similar trend in the frequency range 1-4 kHz has been observed in a previous study [4], in which they have investigated the effect of thickness on Noise Absorption Coefficient (NAC), in the current study, the NRC increases with increasing the thickness from 1- 6 kHz, whereas in the previous study it was observed from 1- 4 kHz, although a direct comparison between Noise Absorption Coefficient and Noise Reduction Coefficient would not be appropriate. For example, NRC includes reduction due to both absorption and reflection while NAC includes only the absorption component.

Increasing in the NRC with increasing the tile thickness might attribute to the nature of energy lost through the transmission path of the sound waves. When noise waves from outside hit the tile the particles inside the tile were excited and start to vibrate. Consequently, the air at other side of the tile started to vibrate creating a wave travelling through the tile. This is called the transmission. In each transmission step, energy of the sound wave lost. It is the energy absorbed by the tile. With the increasing of the thickness, the transmission length also increases resulting to higher energy loss and that might attributed to increase in NRC. However, sound wave in frequencies closer to the natural frequencies (this differ with the material properties) of the tile, the wave transmission is easier and energy loss decrease. Therefore, even though the thickness contributed to increase the NRC, the NRC can be reduced in some frequencies, which are similar to the natural frequency of the material of the tile. Therefore, the increasing of the NRC in one frequency range and decreasing of the NRC in another frequency range can be accepted.

4.1.2 Effect of saw dust particle size

It was found that the tiles cast using large particles have generally greater NRC than that for the tile cast with smaller particles. When the particle diameter is large the void ratio (porosity) increases. On the other hand, the smaller diameter particles can pack well reducing the void ratio. If there are more voids means wave can transmit through the medium well and get dampened. It might contribute to increase the absorption component.

4.1.3 Effect of surface variation of tiles

The shape variation has a significant effect on increasing the noise reduction (Figure 10). In frequencies 7.5 and 8 kHz the NRC values of both tiles were similar. In other frequencies except 5 and 5.5 kHz the NRC of grooved tile has shown higher values than the flat surface tile. Having a grooved surface yields to reflect noise waves more than that from the flat surface. Due to this mechanism, the NRC has increased for the grooved tile more than that for the other tile: tile with a flat surface.

4.1.4 Effect of mix proportion

It can be seen that there is a general increase of NRC with the increasing of mix ratio (Figure 11). With the increase of mix ratio the density of the tile also increases. In a previous study [6] the effect of density towards NAC had discussed. There they had discussed with increase of density the absorption occurs due to increase of flow resistivity. These phenomena can be applied to explain our results.

4.2 Noise Reduction of coconut coir fiber panel

The NRC values for the coir panel having 20mm thickness reached to 0.5 at 8 kHz (Figure 12). In the previous studies [5, 6] the NAC was investigated using different thickness coir fiber panels and using different methods (i.e., Reverberation room, Impedance tube method). They had obtained their peak values around 0.8- 0.9. However direct comparison of the current results with [5, 6] may not be appropriate as NRC was measured in the current study while NAC was measured in the previous studies. In addition, the testing method was also different between studies.

In the present study method, it was not possible to deduct the reflection component of the sound. Effect of environmental noise on the measurements was reduced by conducting the experiment during night times (i.e., calm environment).

5. Conclusions

In this research the Noise Reduction Coefficient (NRC) of the tiles casted by using saw dust and the coconut coir fiber panels were investigated. It was found that NRC increases with increasing the tile thickness, surface roughness, mix proportion and sawdust particle size. It was also found that saw dust and coconut coir fiber, which are natural material, can be used to manufacture tiles or panels with appreciable noise absorption properties. Use of these environmental wastes will reduce environmental pollution. As these materials are often considered as waste, utilization of these materials is more economical and improves sustainability.

Acknowledgement

We express our sincere thanks to the Department of Electrical and Information Engineering and all the others who gave support in many ways for conducting this research.

References

[1]- http://www.who.int/docstore/peh/noise/Comnoise-3.pdf (Visited November-2010)

[2]- http://www.who.int/docstore/peh/noise/Comnoise3.htm (Visited November-2010)

[3]-Miao Lu, Carl Hopkins, Yuyuan Zhao and Gary Seiffert,"Sound Absorption Characteristics of Porous Steel Manufactured by Lost Carbonate Sintering", Vol. 1188 Materials Research Society (2009)

[4]- Rozli Zulkifli, Zulkarnain and Mohd Jailani Mohd Nor, "Noise Control Using Coconut Coir Fiber Sound Absorber with Porous Layer Backing and Perforated Panel", American Journal of Applied Sciences 7 (2): 260-264, 2010

[5]-Rozli Zulkifli, Mohd Jailani, Ahmad Rasdan, Mohd Zaki, Shahrum, Mohd Faizal and Mohd Nizam"Comparison of Acoustic Properties between Coir Fibre and Oil Palm Fibre" European Journal of Scientific Research ISSN 1450-216X Vol.33 No.1 (2009).

[6]- Mohd Jailani, Md.Ayub, Rozli Zulkifi, Nowshad Amin and Mohammad Fouladi, "Effect of different factors on the acoustic absorption of coir fiber", Journal of Applied Sciences 10 (22): 2887 – 2892, 2010